



Ra-01SCH-P Specification

Version V1.1.1

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Document resume

Version	Date	Develop/revise content	Edition	Approve
V1.0.0	2024.06.20	First Edition	Pengfei Dong	Ning Guan
V1.1.1	2025.01.02	Add the description that the module cannot transmit without load, add the description of the input power limit of the module, add the description of the RF_EN pin control voltage time sequence, add the description of the input power limit when the module matches the	Pengfei Dong	Ning Guan

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1. Product overview

Ra-01SCH-P is a LoRa series module designed and developed by Shenzhen Ai-Thinker Technology Co., Ltd. This module is used for ultra-long distance spread spectrum communication. Its RF chip LLCC68+ mainly uses LoRa™ long-range modem for ultra-long distance spread spectrum communication, with strong anti-interference and the ability to minimize current consumption. With the help of SEMTECH's LoRa™ patented modulation technology, the module has built-in power amplifier (PA) and low noise amplifier (LNA) on this basis, with high sensitivity exceeding -137dBm, +29dBm transmission power, long transmission distance and high reliability. At the same time, compared with traditional modulation technology, LoRa™ modulation technology also has obvious advantages in anti-blocking and selection, solving the problem that traditional design solutions cannot take into account distance, anti-interference and power consumption at the same time.

It can be widely used in automatic meter reading, home building automation, security systems, remote irrigation systems, etc.

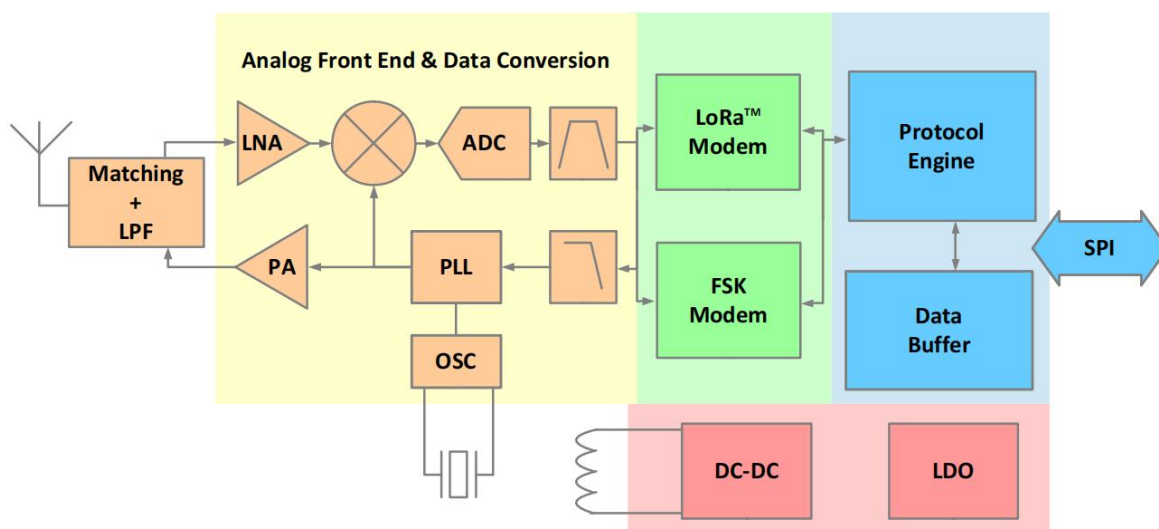


Figure 1 Main chip architecture diagram

1.1. Characteristic

- Support FSK, GFSK, LoRa® modulation
- Support frequency band: 803MHz~930MHz
- Maximum transmit power is optional (see the design guide below for configuration method)
 - ①Default configuration: The internal PA uses a 3.3V power supply voltage. In this state, the maximum Tx Power can reach +29dBm, and the operating current is 750mA;
 - ②Optional configuration: The internal PA uses a 5V power supply voltage. In this state, the maximum Tx Power can reach +31dBm, and the operating current is 1A;
- High sensitivity: as low as -137dBm@SF10 125KHz
- Extremely small size 17*16*3.2(±0.2)MM, double row stamp hole patch package
- Support spreading factors SF5/SF6/SF7/SF8/SF9/SF10/SF11
- It has low power consumption in receiving state, and the minimum receiving current is 16mA
- The module uses SPI interface, half-duplex communication, CRC, and up to 256 bytes of data packet engine
- Support a variety of antenna installation methods, compatible with half-hole pad/through-hole pad/IPEX connector

2. Main parameters

Table 1 Description of the main parameters

Model	Ra-01SCH-P
Package	SMD-16
Size	17*16*3.2(±0.2)MM
Antenna	Compatible with half-hole pad/through-hole pad/IPEX connector
Frequency	803MHz~930MHz
Operating temperature	-40℃~ 85℃
Storage temperature	-40℃~ 125℃, < 90%RH
Power supply	Supply voltage 3.0~3.6V, typical value 3.3V, current greater than 1A
Interface	SPI
Programmable bit rate	Up to 300kbps

2.1. Static electricity requirement

Ra-01SCH-P is an electrostatic sensitive device. Therefore, you need to take special precautions when carrying it.



Figure 2 ESD preventive measures

Notice:

The Ra-01SCH-P module is an electrostatic sensitive device (ESD) and requires special ESD precautions that should generally be applied to ESD sensitive groups. Proper ESD handling and packaging procedures must be used throughout the handling, transportation, and operation of any application incorporating the Ra-01SCH-P module. Do not touch the module with your hands or use a non-antistatic soldering iron for soldering to avoid damaging the module.

2.2. Electrical characteristics

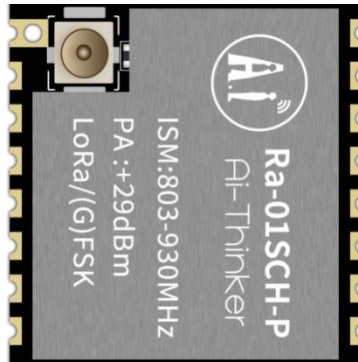
Table 2 Electrical characteristics table

Parameters	Min.	Typical value	Max.	Unit
Power supply voltage 3V3	3.0	3.3	3.6	V
Supply voltage VCCPA	3.0	5	5.25	V
IO Output High Level (VOH)	0.9*VDDIO	-	VDDIO	V
IO Output Low Level (VOL)	0	-	0.1*VDDIO	V
IO Input High Level (VIH)	0.7*VDDIO	-	VDDIO+0.3	V
IO Input Low Level (VIL)	-0.3	-	0.3*VDDIO	V

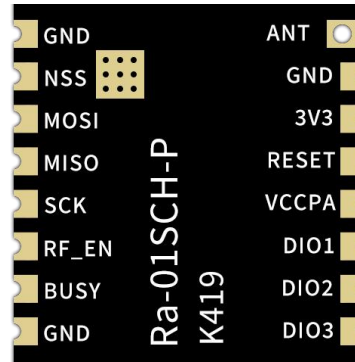
Table 3 SPI interface characteristics

Symbol	Description	Condition	Min.	Typical value	Max.	Unit
Fsck	SCK frequency	-	-	-	10	MHz
tch	SCK high level time	-	50	-	-	ns
tcl	SCK low level time	-	50	-	-	ns
trise	SCK rise time	-	-	5	-	ns
tfall	SCK fall time	-	-	5	-	ns
tsetup	MOSI setup time	From MOSI change to SCK rising edge	30	-	-	ns
thold	MOSI hold time	From SCK rising edge to MOSI change	20	-	-	ns
tnsetup	NSS setup time	From NSS falling edge to SCK rising edge	30	-	-	ns
tnhold	NSS hold time	From SCK falling edge to NSS rising edge, normal mode	100	-	-	ns
tnhigh	NSS high time of SPI access interval	-	20	-	-	ns
T_DATA	DATA hold and setup time	-	250	-	-	ns
Fsck	SCK frequency	-	-	-	-	ns

3. Appearance dimensions

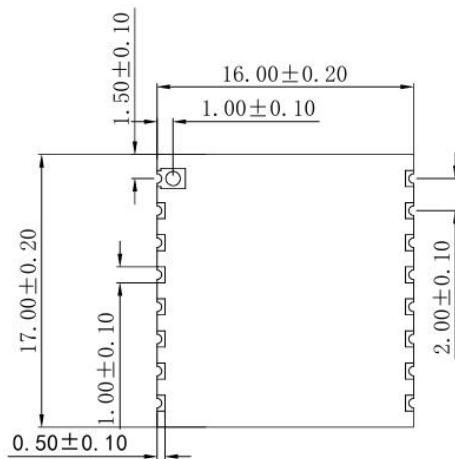


Front

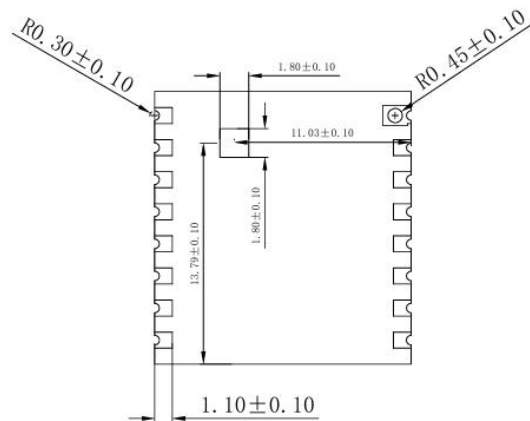


Back

Figure 3 Appearance (rendering is for reference only, the actual object shall prevail)



Front



Back

Figure 4 Dimensions (unit: mm)

4. Pin definition

The Ra-01SCH-P module has a total of 16 pins, as shown in the pin diagram. The pin function definition table is the interface definition.

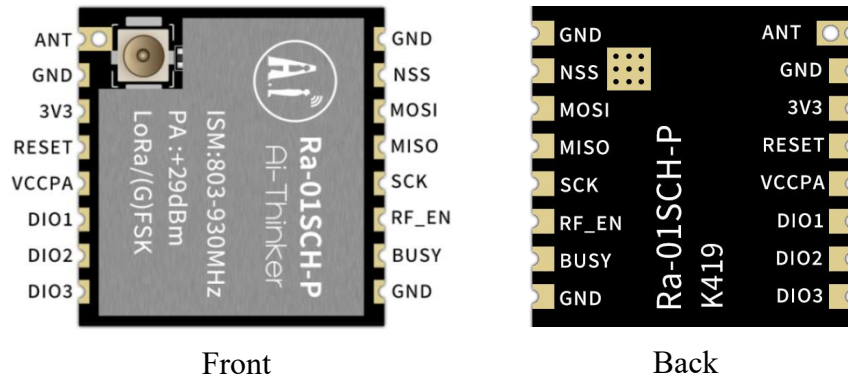


Figure 5 Pin diagram

Table 4 Pin function definition table

No.	Name	Function
1	ANT	Connect antenna
2	GND	Ground
3	3V3	Typical value 3.3V power supply
4	RESET	Reset pin
5	VCCPA	FEM chip power supply pin, input 5V maximum power can reach +31dBm.
6	DIO1	Digital IO1 software configuration
7	DIO2	Digital IO2 software configuration
8	DIO3	Digital IO3 software configuration
9	GND	Ground
10	BUSY	Status indication pin
11	RF_EN	FEM chip enable pin, high level is effective, the module is pulled up by default; high level is in working state, low level is in sleep state
12	SCK	SPI clock input
13	MISO	SPI data output
14	MOSI	SPI data input
15	NSS	SPI chip select input
16	GND	Ground
EPA	GND	Ground, reliable grounding is required to facilitate heat dissipation

The general IO pins of LLCC68+ are available in LoRa™ mode. Their mapping relationship depends on the configuration of the two registers RegDioMapping1 and RegDioMapping2.

Table 5 IO port function mapping table

Operation Mode	DIOx Mapping	DIO3	DIO2	DIO1
All	00	CadDone	Fhss Change Channel	RxRimeout
	01	Valid Header	Fhss Change Channel	Fhss Change Channel
	10	PayloadCrc Error	Fhss Change Channel	CadDetected
	11	-	-	-

5. Schematic

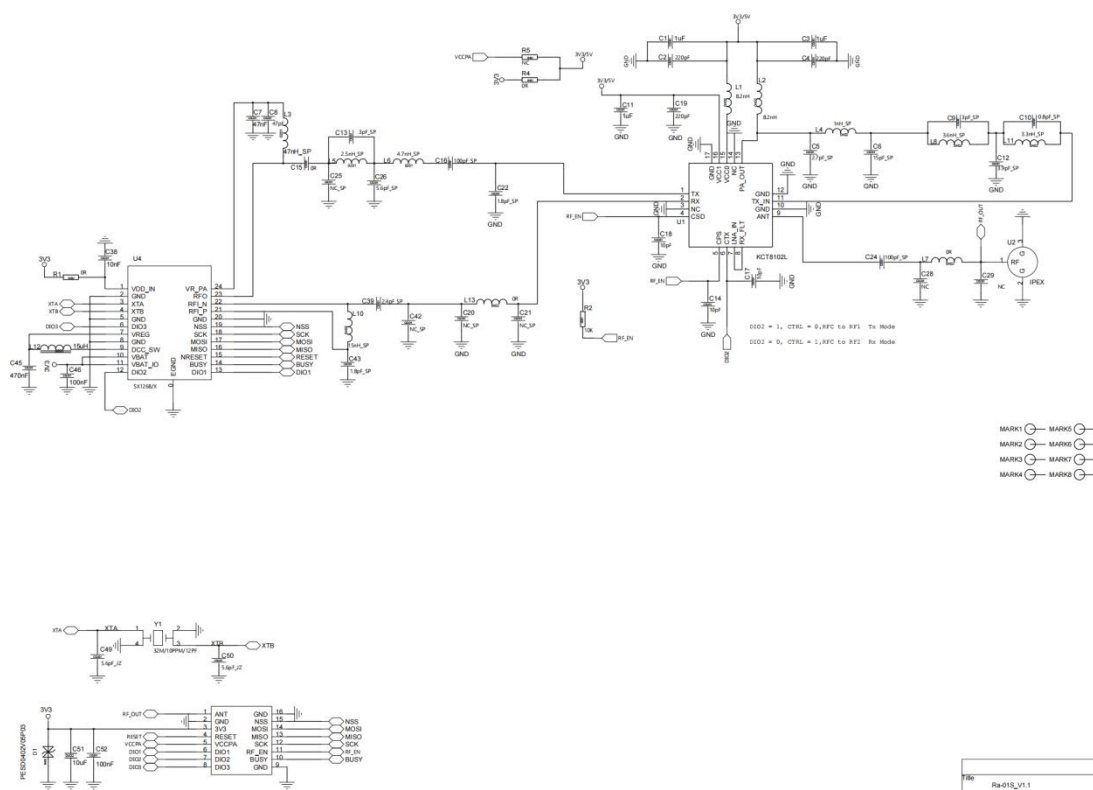


Figure 6 Schematic diagram

6. Design guidance

6.1. Application Guide Circuit

(1) Special pin description

■ About VCCPA pin

- ✓ The PA inside the module supports multiple power supply voltages. When powered by 3.3V, the maximum transmit power of the module can reach +29dBm; when powered by 5V, the maximum transmit power of the module can reach +31dBm.
- ✓ In the default BOM configuration of the module, PA is powered by the 3V3 pin of the module, and the VCCPA pin of the module can be left floating. If PA uses 5V power supply, please contact Ai-Thinker to modify the module BOM and provide 5V power supply to the VCCPA pin of the module.

■ About RF_EN pin

RF_EN is the enable pin of the module's built-in PA chip. When the pin is high, the module's RF is in normal transceiver state; when the pin is low, the module's RF function is turned off, which can reduce the module's power consumption.

The module defaults to BOM, with an internal pull-up resistor of 10K (i.e., it is in normal transceiver state by default). If a low-power working scenario is required, please use an external MCU to control this pin to a low level state. When the level is low, the default pull-up resistor of this pin may have leakage current. If the built-in pull-up resistor is not required, please contact Ai-Thinker to modify the BOM.

Table 6 RF switch truth table

Mode	RF_EN
FEM power off	0
FEM working	1

In summary, the module has four BOM configurations:

Configuration 1: VCCPA is suspended, RF_EN has a built-in pull-up resistor of 10K (default BOM configuration)

Configuration 2: VCCPA is floating, RF_EN has no built-in pull-up resistor

Configuration 3: VCCPA connection, RF_EN built-in pull-up resistor 10K

Configuration 4: VCCPA connected, RF_EN without built-in pull-up resistor

(2) Typical application circuit

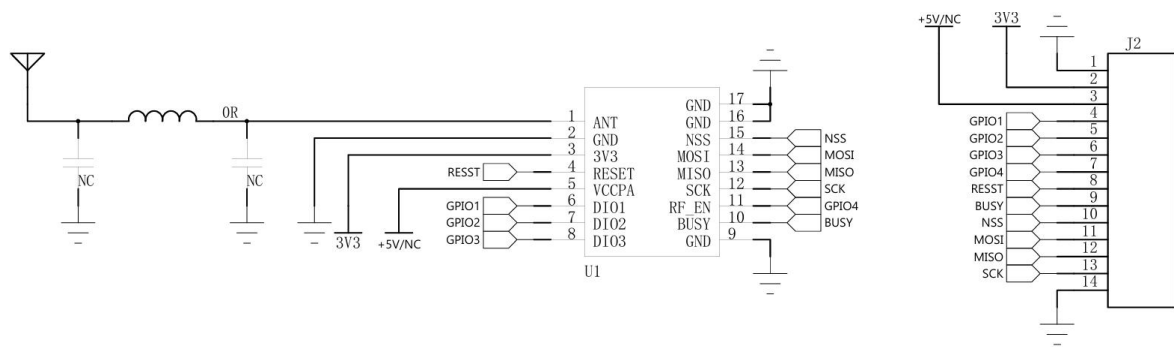


Figure 7 Typical application circuit

- The module's VCCPA is suspended by default. If you need 5V power supply to achieve higher transmission power, please contact Ai-Thinker to modify the BOM.
- RF_EN is recommended for the I/O port control module of an external MCU to achieve low-power application scenarios.
- The transmit power level configured for module LLCC68 cannot be greater than 3dBm. Otherwise, too large a power level will burn out the PA.
- Do not leave the antenna port of the module in the suspended state when the module is in TX transmission, because the VSWR is large during no-load transmission, and the FEM chip has a higher risk of damage; If the ANT port cannot be avoided, the maximum TX input signal power should not exceed 0dBm to ensure that the chip is not damaged.
- The RF_EN voltage of the module must be the recommended value (1.2-3.6V) and the pin voltage cannot exceed the power supply voltage of module 3V3. Ensure that module 3V3 is powered on before RF_EN.
- During the antenna matching and debugging process, the impedance may not match, resulting in a large VSWR. During this process, it is recommended not to directly generate saturated power to avoid excessive damage to the chip due to VSWR. After the antenna impedance debugging is completed, the saturation power is generated again.
- The power supply current must meet the specifications. If the current is limited, the saturated power cannot be pushed up.

(3) Other instruction

- The communication interface with the main control MCU, in addition to the SPI interface, also needs to connect BUSY/DIO1 to the IO port of the main control MCU.

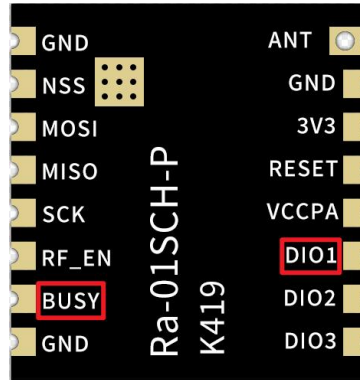


Figure 8 BUSY/DIO1 application considerations

- The antenna is soldered on the main control board. It is recommended to reserve a pie-shaped matching circuit at the antenna interface.

6.2. Recommended PCB package size

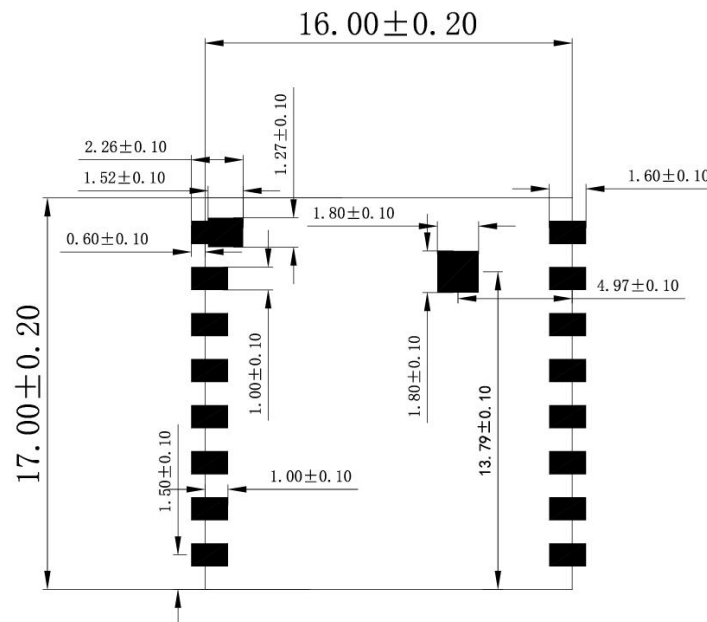


Figure 9 Recommended PCB package dimensions (unit: mm)

6.3. Antenna Installation

- Ra-01SCH-P requires an external antenna. There is a half-hole solder pad on the module that can be connected to the main-board.
- In order for the antenna to achieve the best effect, the antenna should be installed away

from metal parts.

- The antenna installation structure has a great impact on the performance of the module. Make sure the antenna is exposed and preferably vertically upward. When the module is installed inside the housing, you can use a high-quality antenna extension cable to extend the antenna to the outside of the housing.
- The antenna must not be installed inside a metal shell, as this will greatly reduce the transmission distance.

6.4. Power supply

- The recommended voltage is 3.3V and the peak current is above 1A.
- If using DC-DC, it is recommended that the ripple be controlled within 100mV.
- It is recommended to reserve space for dynamic response capacitors in the DC-DC power supply circuit to optimize the output ripple when the load changes greatly.
- It is recommended to add ESD devices to the 3.3V power interface.
- When designing the power supply circuit for the module, it is recommended to retain a margin of more than 30% for the power supply current, which will help the whole machine to work stably for a long time.
- Please pay attention to the correct connection of the positive and negative poles of the power supply. Reverse connection may cause permanent damage to the module.

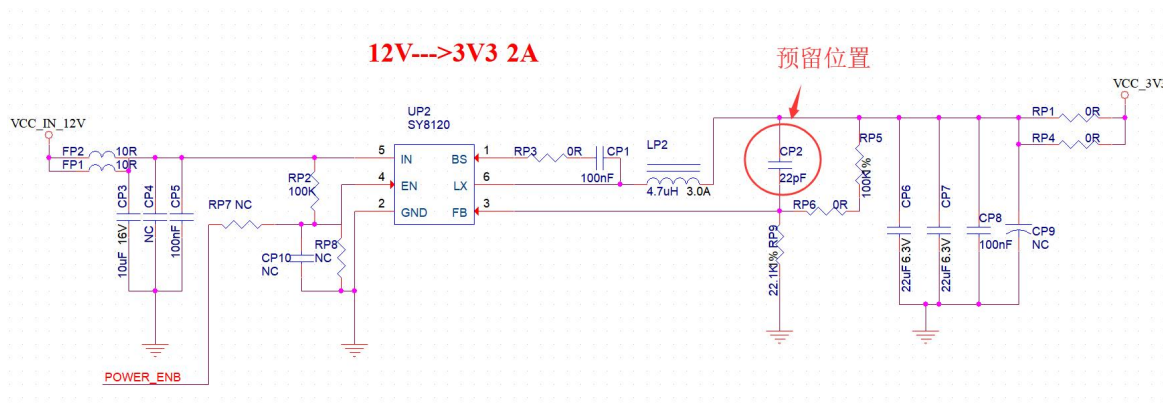


Figure 10 DC-DC buck circuit

6.5. GPIO level conversion

- Some IO ports are connected to the module. If you need to use them, it is recommended to connect a 10-100 ohm resistor in series to the IO ports. This can suppress overshoot and make the levels on both sides more stable. It is helpful for EMI and ESD.
- For the pull-up and pull-down of special IO ports, please refer to the instructions in the specification, which will affect the startup configuration of the module.
- The IO port of the module is 3.3V. If the IO port levels of the main control and the module do not match, a level conversion circuit needs to be added.
- If the IO port is directly connected to a peripheral interface, or terminals such as a pin header, it is recommended to reserve ESD devices near the terminals in the IO port routing.

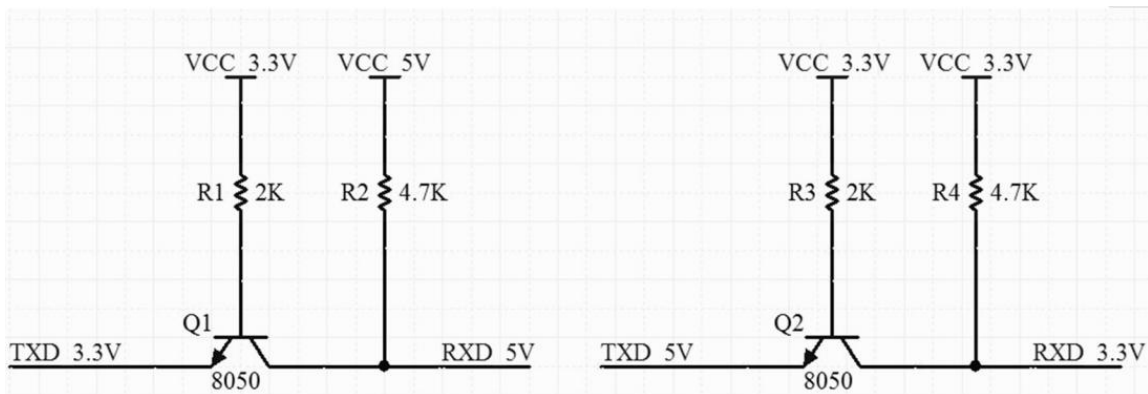


Figure 11 Level conversion circuit

6.6. Software Writing

- The maximum input power of the FEM chip cannot exceed +3dBm, otherwise the FEM chip will burn out. Users need to strictly configure the output power of LLCC68, 0dBm to 3dBm is recommended.
- This module is LLCC68+ peripheral circuit, and users can operate it completely according to the LLCC68 chip manual.
- DIO1/DIO2 are general IO ports that can be configured with multiple functions.
- The control of the RF switch TX/RX can be controlled by an external MCU or jointly by an external MCU and DIO2 of LLCC68.
- Differences between LLCC68 and SX1262/SX1268:

(1) SX1262/SX1268 supports spreading factors SF5, SF6, SF7, SF8, SF9, SF10, SF11, SF12;
SX1262/SX1268 configurable spreading factor and receiving bandwidth

LoRa@ Rx/Tx, BW = 7.8 - 500 kHz,

SF5 TO SF12, BR=0.018 - 62.5 Kb/S

(2) LLCC68 supports spreading factors SF5, SF6, SF7, SF8, SF9, SF10, SF11;
LLCC68 can set the spreading factor and receiving bandwidth

LoRa@ Rx/Tx, BW = 125 - 250 - 500 kHz,

LoRa@, SF=5-6-7-8-9 for BW=125kHz,

LoRa@, SF=5-6-7-8-9-10 for BW =250 kHz,

LoRa@, SF=5-6-7-8-9-10-11 for BW=500 kHz.

7. FAQ

7.1. Factors affecting transmission distance

- When there is a straight-line communication obstacle, the communication distance will be attenuated accordingly.
- Temperature, humidity, and co-frequency interference will lead to an increase in the communication packet loss rate.
- The ground absorbs and reflects radio waves, so the test effect is poor near the ground.
- Seawater has a strong ability to absorb radio waves, so the test effect is poor at the seaside.
- There are metal objects near the antenna, or it is placed in a metal shell, the signal attenuation will be very serious.
- The power register is set incorrectly, and the air rate is set too high (the higher the air rate, the closer the distance).
- The low voltage of the power supply at room temperature is lower than the recommended value. The lower the voltage, the lower the power.
- The antenna used is poorly matched with the module or the antenna itself has quality problems.

7.2. Module usage precautions

- Check the power supply to ensure that it is within the recommended power supply voltage. If it exceeds the maximum value, the module will be permanently damaged.
- Check the stability of the power supply. The voltage cannot fluctuate frequently and significantly.
- Ensure anti-static operation during installation and use. High-frequency components are sensitive to static electricity.
- Ensure that the humidity during installation and use is not too high. Some components are humidity-sensitive devices.
- If there is no special requirement, it is not recommended to use it at too high or too low temperature.

7.3. Factors that interfere with the module

- There is interference from the same frequency signal nearby, stay away from the interference source or change the frequency or channel to avoid interference.
- The clock waveform on the SPI is not standard, check whether there is interference on the SPI line, and the SPI bus line should not be too long.
- Unsatisfactory power supply may also cause garbled code, so the reliability of the power supply must be ensured.
- Poor or too long extension line or feeder line will also cause a high bit error rate.

8. Storage conditions

Products sealed in moisture-proof bags should be stored in a non-condensing atmosphere of $<40^{\circ}\text{C}/90\%\text{RH}$.

The module's moisture sensitivity level MSL is level 3.

After the vacuum bag is unsealed, it must be used within 168 hours at $25 \pm 5^{\circ}\text{C}/60\%\text{RH}$, otherwise it needs to be baked before it can be put online again.

9. Reflow soldering curve

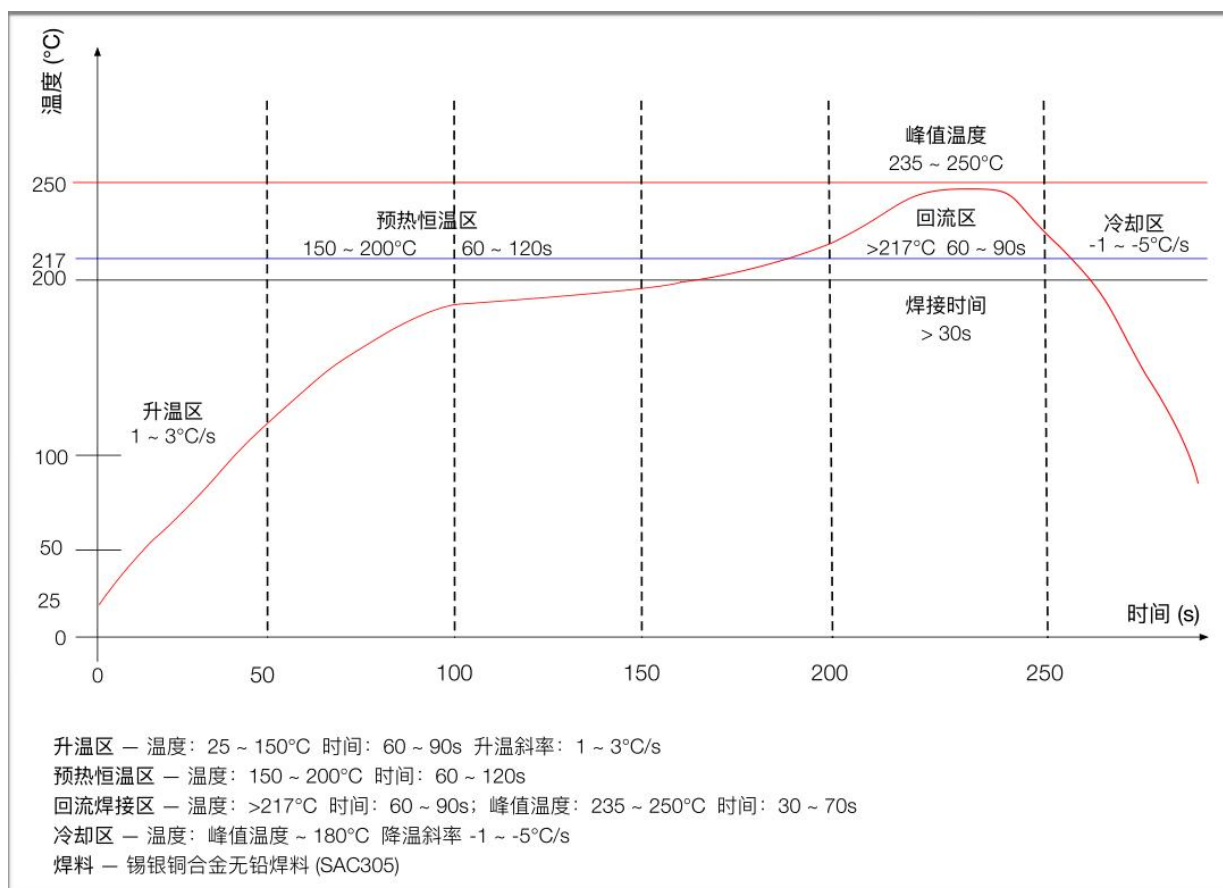


Figure 12 Reflow soldering curve

10. Product packaging information

As shown in the figure below, the packaging of Ra-01SCH-P is braided tape, 800pcs/reel. As shown in the figure below:



Figure 13 Packaging and taping diagram

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